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A crucial step for either initial issue development or post deployment support updates of military software products is integrated systems testing. After the development team has conducted progressive coding/module level tests and appropriate systems integration tests (using a systems integration laboratory), a proposed new version for the software product emerges. The critical issue becomes "Is this version ready for final operational testing and for release for use by our military users?". During Developmental Test and Evaluation (DT&E), each proposed new version is subjected to integrated systems testing. The configuration item is installed into representatively configured military hardware system (aircraft, ships, etc.). During testing, it is operated in the near-operational environment (at sea or in flight, using highly skilled military operators performing a carefully planned representative task). The authors are team members of Naval Helicopter software development Integrated Program Teams (IPTs). Their pragmatic experiences in performing this value added testing in the near-operational environment is useful for consideration by all software developers and testers.

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1.0 INTRODUCTION[1]

A crucial step for either initial issue development or post deployment support updates of military software products is integrated systems testing. After the development team has conducted progressive coding/module level tests and appropriate systems integration tests (using a systems integration laboratory), a proposed new version for the software product emerges. The critical issue becomes "Is this version ready for final operational testing and for release for use by our military users?". During Developmental Test and Evaluation (DT&E), each proposed new version is subjected to integrated systems testing. The configuration item is installed into representatively configured military hardware system (aircraft, ships, etc.). During testing, it is operated in the near-operational environment (at sea or in flight, using highly skilled military operators performing a carefully planned representative task). The authors are team members of Naval Helicopter software development Integrated Program Teams (IPTs). Their pragmatic experiences in performing this value added testing in the near-operational environment is useful for consideration by all software developers and testers.

Employees of the Naval Air Warfare Center (NAWC) participate in a partnership of organizations which work together on the IPTs to provide high quality, technologically superior products and support to the customers of the Naval Air Systems Command (NAVAIRSYSCOM). They are part of the test teams responsible for testing and supporting aircraft/related systems that can be operated, based or sustained at sea. The authors competency group is the newly created Tactical Data Systems Branch (TDSB, code 4.11.7.1) in the Test and Evaluation Engineering Department, responsible for providing personnel, processes and facilities to IPTs. They perform the DT&E of integrated avionics systems, which include new or modified software, and integration of software into avionics and hardware components.

In the near-operational environment, IPTs conduct detailed technical tests which include the use of various shore-based facilities with operationally equipped aircraft. Specialists in real-time data acquisition, range tracking/control, acoustics simulation, electronic warfare simulation, and command and control participate in each airborne test program. They contribute the necessary technical expertise to evaluate system performance at both the technical and operational levels. Aircrews are hand picked because of their significant operational experience and personal motivation which contribute to the realism built into each test. Together, this

[1] Reference (a) Naval Aviation Systems Team 1994/95 Strategic Plan

Encl (1)

confluence of personnel, equipment and technical insight provide the backdrop for the near-operational environment.

1.1 SOFTWARE DEVELOPMENT PROCESS[2]

As part of the military software development process, the Department of Defense has established a formalized series of milestones that combine to control and influence software production process. Technical reviews are held for the completion of major tasks before committing further resources in what may turn out to be a risk-laden development. The purpose of the software development process is to define requirements early in the process and decide how to implement them. Different levels of testing are appropriate at distinct stages of the process (code, module, simulation/stimulation, etc.). DT&E engineers follow the software development process and are able to give advise to software designers in terms of mission relation. Participation by test engineers allows technical problems to be caught early on in the development cycle.

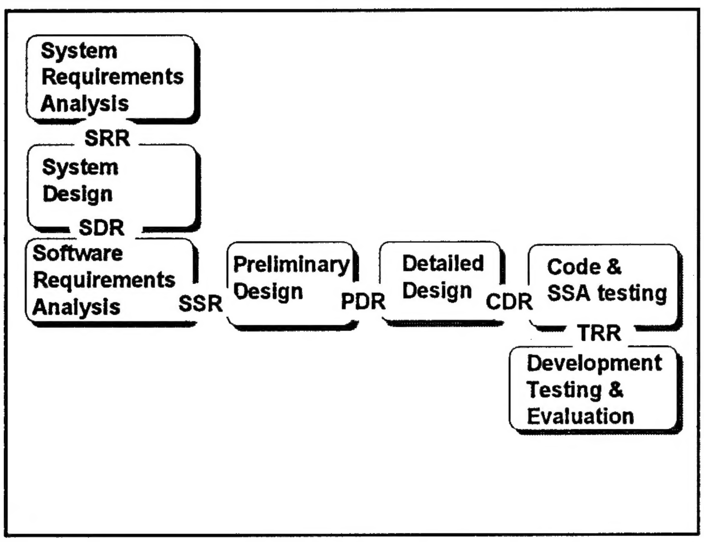

Figure 1.
Software Development Process

[2] Reference (a) DOD-STD-2167A, Military System Software Development

The software development effort consists of seven activities, Figure 1, which when combined lead to methodically created software developed and tested in controlled environments: (1) system requirements analysis, (2) system design, (3) software requirements analysis and definition, (4) preliminary design, (5) detailed design, (6) coding, unit and module level testing, and (7) DT&E. At the end of each of these activities are reviews (System Requirements Review, System Design Review, Software Specification Review, Preliminary Design Review, Detailed Design Review, Test Readiness Review) which are held to determine the completion of the activity and the capability to proceed to the next activity. IPT management personnel support the development effort by continuously reviewing and updating the plan of action and milestones, thus ensuring that the process remains on track. Competency management also supports the process by providing the necessary resources (personnel, aircraft and facilities) to complete each task and qualified staffing, for IPT support performance on a periodic basis. The advantages of formalizing the development process include lower development costs, shorter development times, and fewer systematic errors in the finalized code. DT&E project engineers actively participate as IPT team members throughout the software development process. Their special role as installed systems testers becomes activated once the proposed software product reaches the DT&E phase.

1.1.1Software Developmental Test and Evaluation

The goals of the DT&E are to ensure that installed avionics and software systems meet the software requirements, are mission ready and ready for Operational Test and Evaluation (OT&E). DT&E addresses the issues of the appropriateness of the crew-system interface, system performance under near operational conditions, software reliability and software safety. The need for control of the test environment during DT&E is met through the use of sophisticated test facilities which include the Ship Ground Station (SGS), the Helicopter Mission Systems Support Center (HMSSC), Chesapeake Test Range (CTR) and the Mid-Atlantic Test Range. They provide the capability to execute full-up mission profiles for Anti-Subsurface Warfare, Electronic Support, Surface Radar tracking, or weapons delivery. The near-operational environment may include multiple ship/air platforms for certain test scenarios, but are typically designed for simplicity and to minimize cost.

Software DT&E is conducted to ensure installed software specification compliance of an operational system in its intended environment. A major portion of DT&E consists of planning, conducting tests and reporting test results of aircraft and weapon systems software. Testing evaluates the new or modified systems performance, reliability, interoperability, safety, and crew-system interface throughout the range of operational factors. Test results are analyzed and evaluated to determine requirements' compliance, mission suitability and readiness for the user. The overriding purpose of DT&E is to translate test data and mission relation into information for acquisition decisions, future design improvements and/or deficiency corrections. DT&E is conducted before OT&E to support the acquisition decision for initial operational capability or supports the sequence of events leading to lifecycle updates of inservice software and helicopters.

1.1.2 Operational Evaluation

In general, OT&E is the last testing performed on the software before it is released to the fleet. The purpose of OT&E is to evaluate the effectiveness and suitability of the software as installed in the system. OT&E certifies the software for fleet release and ensures its operational effectiveness while identifying deficiencies. It differs from DT&E in that the aircrew and support personnel conducting the testing are representative of the type of personnel in the fleet. The environment for OT&E goes one step beyond DT&E in that it mimics the environment which will be experienced under fleet use conditions.

2.0 TEST METHODOLOGY

2.1 TEST AND EVALUATION FACTORS

A typical DT&E evaluation of software consists of a documentation review before delivery, then planned laboratory, ground and flight tests after software delivery. Typical software products provide new functions and correct prior problems (previously document by deficiencies report). During DT&E, the following four factors are considered: subjects, criteria, procedures and controls, and setting[3].

(a) **Subjects**: Each evaluation is carried out with personnel who use the software in as fleet operators will use it. Operators are selected based on their knowledge of the system being tested and are trained to recognize the performance differences of the new software can exhibit. For example, a test team will include test pilots, highly skilled aircrew, and software/computer professionals.

(b) **Criteria**: Each test effort consists of test metrics such as system loading time, system readiness criteria (which are based on mission needs), equipment maintainability, and the number of software errors detected. For software, which requires significant aircrew dexterity (e.g., like intercepting a constantly changing circular course), the aircrew evaluate the software against standardized handling qualities rating scales[4].

(c) **Procedures and Controls**: Procedures for each test evolution contain the step-by-step (not necessarily keystroke-by-keystroke) methods needed to produce the desired evaluation results. Each deficiency report (STR or Yellow Sheet), documented during previous evaluations, is broken down into constituent steps and then worked into a scenario which presents the

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[3] adapted from Cognitive Ergonomics-Understanding, Learning, and Designing Human-Computer Interaction; 1990.

4 Cooper-Harper Handling Rating Systems, NASA

operator with situations that he or she is likely to encounter. These scenarios are written in flight cards or ground test procedures. Since not every problem possibility can be covered this way, test scenarios focus on the most likely to occur situations, plus high density or stressed situations (large number of targets, etc).

(d) **Setting:** To properly evaluate the system we test it under conditions as close as possible to those under which it will be used operationally. The operational environment and the test environment must each be separately analyzed and common elements must be found which fall within the constraints of the project budget and time allocated. The use of operational equipment, (ship, aircraft, and mission data recording equipment) enhances the overall simulation of performing an actual mission but can significantly increase the cost of testing if it must be separately acquired; the use of common element end items is maximized whenever possible. The layout and organization of the test facility are also used to exploit the operational characteristics of the equipment.

2.2 SOFTWARE DESIGN

For software driven systems, the primary crew-system interface for data entry and display can be a Control and Display Unit (CDU) or Multipurpose Display (MPD) with keyset panel. The most common functions to be evaluated for these units are:

- Entry of data required at initialization and data modification during flight,
- Upload and download of data from external devices,
- Built-in-Tests (BIT) and check of equipment status,
- Entry, display and modification of all data pages and data bases,
- Data display and control of all communications and navigation radios,
- Entry and display of tactical and acoustic data.

Two of the most common system designs include fixed function key entry systems and menu-driven page entry systems. Each has distinctive advantages that affect the cost, weight and crew-system interface design.

2.2.1 Key Entry

In the point entry system environment, fixed function keys are evaluated for use in gaining access to functions critical to the aircrew operator. Depression of a key must result in a system response to perform an action or change a mode. A selection of a key can result in the action of display of a sonobuoy, fly-to-point, or reference mark on the MPD. A mode change can be caused by a single key entry, such as a requirement to switch control from the HELO controlled to a SHIP controlled environment. Depressions of this key result in the aircraft computer sending a message to the ship to take control of certain airborne subsystem functions. The point entry system is developed so that when a key has been selected it is backlit active (green) and all corresponding selectable keys are backlit available (white). All keys that

are not available are not illuminated. This system allows the aircrew to make quick responses to data entry tableaus. For mission systems involving a relatively flat menu structure, the point entry system often is cost effective and has minimal impact on operator training.

2.2.2 Menu Driven System[5]

Most menu systems are evaluated as hierarchical trees, verifying each node (menu panel) in the hierarchy can be reached only from a single superordinate node that lies directly above it in the hierarchy. In military aircraft systems, options may include a choice of weapons, launch modes to employ, creation of flight plans, and communication plans. In most of these systems the information is organized in data pages. Pages are linked lists, like "trees" where the "root" of the tree is reached by a single keyboard switch (NAV, COM, IFF, etc.). Subsequent pages inside a list or tree are accessed using a line select switch or a toggle switch. Certain functions and text are dynamic and are removed from the display in situations where the function/text does not apply. The options for each panel will determine the software menu pathways, the sequence of selections that will be required to get from one menu panel to next. Menu-driven systems must handle a complex menu structure but are limited by the amount of the workload imposed on the aircrew. The operator workload on various phases of a typical mission is a key evaluation criteria (often qualitatively assessed).

2.3 TESTING APPROACHES

2.3.1 System Performance

System performance is measured by executing the test plan and procedures designed by the project engineers. Software test procedures are designed to execute specific software functions within the context of operational scenarios. While not every procedure is based on an operational scenario, each procedure will specify a series of steps executed with operational equipment. For example, to evaluate the performance of a tracking algorithm generated by a RADAR system, a scenario would be devised which would allow external control of target parameters (such as course, speed, altitude and heading and require the operator to select a tracking mode, filter integration time, display configuration) and interact with the tactical display system. Variations in the aircraft flight parameters can be accounted for through on-board data extraction or RADAR range tracking in circumstances where additional costs are warranted.

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5 Reference (a) Paap, K., and Roske-Hofstrand, R. (1986). The Optimal Number of Menu Options per Panel. The Journal of Human Factors Society, Vol. 28 No.4 August 1986.

Measures of system performance include subjective evaluations by the aircrew and/or system operators. Technical metrics data includes measurement times for system loading, initialization, data bus loading, data precision characteristics, subsystem response times and data latency, operator workload, and other parameters required to evaluate the system performance with the new software configuration. Aircraft are required to be mission ready within a given time period. System performance testing verifies the capability of the aircraft to load and be ready for use in this time.

Software system tests are conducted using prearranged flight profiles designed to provide technical data on one or more parameters associated with a particular function or set of functions in scenarios which are as close to being mission-related as possible. For example, Anti-Subsurface Warfare testing comprises the use of target tracking functions used against real or simulated targets. Electronic Warfare suites are usually baselined by using real aircraft in simulated environments, but ultimately get tested in flight on a test range against actual electronic systems. The use of flight time is maximized by extensive use of aircraft ground test facilities. The technical parameters are controlled so that post-mission data analysis will yield performance parameters as they are called out in the project test plan.

2.3.2 Crew-System Interface[6]

The introduction of on-board computers has changed the role of the test pilot and project engineer in terms of crew-system interface. A goal in evaluating the crew-system interface is to recognize the underlying cognitive structure of a computer task and determine its effects on the operator's performance in a divided-attention context. When designing equipment, computer software, and procedures for use in military environments, it is essential to understand the relationship between design features and the capability of the operator to perform all timesharing duties safely and efficiently. Compatibility of control/display interfaces and procedures with human information processing capability, decision making effectiveness, and limits of short-term and long term memory and computational skills are of paramount importance. The optimal matching of the software (i.e., the "thought processes" of the aircraft systems) to the thought processes of the pilot, has become perhaps the major human factor challenge in the design of civil/military aircraft computers. If the pilot does not understand the frame of reference and the logical processes underlying an aircraft's automated systems, a communication breakdown between pilot and aircraft may be the result. Consequently, the decision-making capability of the pilot or crew would be severely degraded. The aircraft computers have to be user-friendly and must allow a meaningful dialogue with the aircrew to facilitate decision making. The goal is to create user-friendly computer systems, not a computer-friendly aircrew.

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6 References (a) Lee, R.B. (1989) Communications and Decision Making in the Glass Cockpit, Human Factors 7 Aviation Medicine, Vol. 36 No.6 Nov/Dec 1989

(b) Salvendy G. (1987). Handbook of Human Factors. John Wiley & Sons, Inc.

As part of the evaluation of software display presentation, the following components are analyzed: the expected number of alternatives that a user examines on a page, the time required to read or process an alternative, key-press time, the time required to register a choice, and the time required to accomplish the ultimate task. Test procedures are developed to exercise specific mission tasks and evaluate the crew-system interface. Flight crews provide subjective evaluations of menu structures, data entry capability, function usability, and provide considerable insight on system setups during flight testing.

Some variables that have been found to affect the relative merits of the crew-system interface in relation to entry and selection in a computer-driven system include familiarity with the software, the difficulty users have in spelling items in the program (when alphanumeric entries are required), the total size of the data base, whether entry methods are aided, and the number of menu levels in the design.

2.3.3 Software Reliability

Software reliability is an important aspect of the software development testing process. This process begins with the planning phase and continues through the software lifecycle. During the development phase, software reliability is maintained through oversight of the developer's activities and independent analysis of it's generated data items (i.e., software metrics, software requirements analyses, program performance specifications, etc.).

While keeping in mind the overall system design and its mission, test engineers review and evaluate software requirements, design specifications, and the software development plan to ensure that the developer is following the agreed upon software development, is addressing all of the system requirements, and is meeting project milestones. At each milestone, the contractor must present the status of each contract deliverable for the software and review the progress to date for each task. All of this assures the government that, when the development process is finished, the final product will be supportable and maintainable.

During the development phase, NAWCAD maintains a trouble report tracking system that allows for following contractor progress and monitoring contractor activities. Test engineers constantly review the latest developments in the project by visiting the developer's site and attending program reviews. When deliverables are due, test engineers are responsible for reviewing documentation, submitting comments where appropriate, and attending document inspections as government witnesses.

Software reliability includes software loading verification testing, regression testing and validation testing. Software loading verification is the capability to load, reload during flight, and successfully load the software within time limits or mission requirements. Regression

testing is "selective retesting of a system or component to verify that modifications have not caused unintended effects and that the system or component still compiles with its specified requirements[7]." Validation testing addresses corrections or enhancements to the new software version to ensure that the new requirements imposed on the system are actually implemented. So unlike the process of verification, which seeks to determine if all of the software requirements are met by the proposed code changes, validation is the process of ensuring that the code meets all the system software requirements.

Software stress testing is another measure of software reliability used to predict the performance of a software system under dynamic conditions. Software stress test procedures include using maximally loaded libraries, inventory tables, and symbology displays besides creating equipment faults or processing high cyclic rate tasks. It consists of procedures that maximize the cyclic processing requirements of the software and involves running as many functions as possible at the same time to test the limits of the computer system. Additionally, the software is run for two or more mission cycles without reloading. This part of stress testing will determine if the system/software is capable of performing for extended periods without failure.

2.3.4 Software Safety

All approaches to software testing are critical and can impact the safety of the software. If the software does not perform as predicted, this can cause confusion and mission degradation, thus impacting mission accomplishment and ultimately the safety of the aircrew. Safety must address how negative system performance would impact mission accomplishment and the safety of the aircrew and surrounding friendly forces.

As part of the development process, the contractor is required to perform a software safety analysis. Usually, the safety analysis is performed with a failure analysis that points out single-point failures that can occur during system operation. The safety analysis reviews software requirements, software design, operating procedures and identifies potential hazards due to the software. For each hazard sited, a risk assessment is performed and a mitigation plan is formulated. During DT&E, the safety analysis is used to formulate test procedures that provide a safety margin to the aircrew in case of failure.

The crew-system interface addresses how safety information is presented to the operator. The alert presentation on a display is very important for aircrew safety. For example, if the aircrew is not properly notified by display or aural indication of a change in status of the aircraft (e.g., low altitude alert, inertial navigation set failure), the results can be catastrophic. In such cases, multiple paths are added to the software to present the warning indication. As a result, the indication may appear visually and trip an aural alarm, so if the pilot does not see the first

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[7]IEEE Standards Collection Software Engineering, 1993 Edition page 61

indicator he/she will hear the second one. In cases where the crew survivability is at stake, warning indicators are hardwired into the appropriate systems.

Frequently the software safety aspects are not always clearly identified, as when an alert or mode change is displayed to an operator. At times a complex evaluation of many inputs from all testing approaches is required to determine the level of criticality of the software hazard to mission accomplishment and suitability of the software for fleet use.

3.0 RESULTS

Data reduction for software flight testing involves deciding the input-output characteristics of the underlying subsystem and measuring quantities that explain software performance. Test data is either electronic or handwritten in the form of data cards. Within the HMSSC at Rotary Wing, the LAMPS MK III program has developed the ALADIN (Automated LAMPS Data Integrated Network) system to perform the task of data reduction and conversion into engineering reports. Other systems in use include the HV data logger, Loral SBA-100 Bus analyzer, and the MARS 2000 Tape Instrumentation System. For example, the LAMPS data analysis routines were developed in-house at NAWCAD, but software such as BBN Probe and PV Wave are available as well. The cognizant engineer must decide which equipment will best capture the data he or she wants and which software package will display that data most expeditiously.

3.1 DATA COLLECTION

3.1.1 Manual Data Collection

Even in today's electronic environment, the manual collection of data is still required and is one of the best ways to ensure that some data is collected, especially if the electronic means fail. During ground events, project engineers manually record information on flight data sheets and constantly observe the system for actions and/or events that do not appear correct. Manual inspection of displays and recording of results are at the forefront in determining if anomalies exist in the system.

Pilots and aircrew are a valuable asset for data collection. Each flight is thoroughly debriefed and the aircrew is queried regarding the suitability and ease of use of the software and its functions. After the flight event, the aircrew provides a written report to the test engineer. Debriefings and flight report dailies are means by which operators provide a fleet operator's perspective of the software and system.

The aircrew manually records information during the flight. Before the flight, the project engineer briefs the aircrew on the purpose of flight, procedure(s), and what data is to be

recorded. The aircrew records this information on kneeboard data cards, and other information that they deem to be of value. The project engineer must be diligent in creating the flight cards/data cards to include not only direct data that will be recorded but also any relative data that may explain unexpected results. Flight cards should contain contingency steps to be taken when unexpected results do occur.

3.1.2 Test Instrumentation

Test instrumentation is equipment installed on the aircraft that is not part of the aircraft operational configuration. The express purpose of the test instrumentation is to retrieve data for use in post-test analyses. NAWCAD capabilities also include real-time telemetry for tests involving flight critical maneuvers. Approval for instrumentation is granted locally but for those tests involving flight controls or aerodynamics, approval authority rests with TEAM 4.3.

3.1.2.1 Data Bus Instrumentation

Most Navy aircraft use an MIL-STD-1553 data bus to control aircraft sensors and read data from the sensors for processing. Data bus instrumentation is used to trap communication between the mission computer and remote terminals (RT) or obtain data directly from a terminal. This instrumentation can be set up to either monitor the bus during flight or simulate the responses of one or more terminals. Once a problem is cited, the bus analyzer can be used to troubleshoot or to simulate the problem.

Ruggedized computer systems are used to retrieve data through special test ports. The ruggedized systems allow for the installation of flexible test instrumentation systems on the test aircraft without requiring extensive vibration analysis of that equipment. Specially designed and pre-approved pallets are used to secure the instrumentation in place in the aircraft and tie the power systems directly into the avionics system electrical bus. This means that once a project is approved locally, installation and checkout of the on-board systems can begin immediately.

3.1.3 Video/Audio Recorders

Video and audio recorders are installed on the aircraft to capture real-time information about what is occurring on the aircraft. The audio recorder will capture flight crew conversations, air traffic control instructions and test engineer instructions. Video recorders can be focused on the displays and keysets to allow reconstruction of the mission for software analysis. Together, this instrumentation provides a full mission playback capability within the HMSSC.

3.1.4 On-line Data Extraction Systems

On line data extraction systems are equipment or software that is part of the fleet aircraft configuration or part of kit installed into a fleet aircraft. These systems allow test engineers to

evaluate the performance of the aircrew, the aircraft subsystems, or the aircraft computer system under more realistic scenarios because recording goes on continuously without operator intervention. This data can be used to evaluate aircrew or software performance when the aircraft cannot be flight tested (such as when fleet aircraft are used to evaluate new products or techniques).

3.1.4.1 Mission Recorders

The Mission Tape Recorder Unit provides a permanent record of mission information. Extraction and recording of information include tactical data, navigation parameters, system status parameters, tactical situation parameters, acoustic data, voice communication and mission time. These tapes can be played back in the HMSSC to reconstruct a flight.

3.1.4.2 Mission software data extraction

On some aircraft the capability to extract data is built into the mission software. The SH-60B mission software data extraction program automatically logs parameters computed by each subsystem functional area and records the data in fixed length records on the aircraft's magnetic tape system. Included within this parameter set are the host computer performance measures such as I/O times, number of interrupts issued, module processing time, I/O faults recorded and I/O utilization parameters. The data extraction function also records data that can commonly be found on the aircraft 1553 bus such as mark-on-top positions, navigation parameters, radio tuning commands, keyset depressions, and others.

3.1.5 Laboratories

The use of laboratories for simulation and scenario control is a vital part of testing. Laboratories provide support for engineering development testing, Independent Verification and Validation, DT&E, and provide a variety of capabilities:

- To control or create part of the environment,
- To collect data during testing,
- To analyze data collected during testing,
- To recreate flight tests,
- To troubleshoot problems,
- To simulate testing before flight testing,
- To review test procedures or documentation,

Some laboratories provided for use by the TDSB to the IPTs are described below.

3.1.5.1 Ship Ground Station

The SGS is used to support DT&E for airborne components, shipboard electronics, and the entire LAMPS MK III integrated ship/air system. The SGS is capable of establishing a data link between test aircraft or fleet configured aircraft and the AEGIS Combat Systems (ACSC), Wallops Island, VA, for simulation in an AEGIS system combat environment. The SGS can also be linked via the ACSC to an SH-60B helicopter flying off shore over the Atlantic. SGS includes a production configured NAVSEA shipboard TACNAV bursted data link capability. To simulate underwater targets, the SGS is equipped with a production On-Board Trainer (OBT) which can provide the aircraft with a complete ASW scenario.

3.1.5.2 Chesapeake Test Range

CTR provides telemetry, tracking data and range control all in a centralized workstation allowing analysis and display of flight measurements in real-time. Other capabilities include electronic warfare threat simulation and long range tracking providing meter-level Time-Space-Position Information. CTR develops specialized instrumentation packages and methods to increase airborne data accuracy and throughput.

3.1.5.3 Helicopter Mission System Support Center

The HMSSC located at the Rotary Wing Aircraft Test Squadron hangar supports all rotary wing flight tests with computer hardware and software necessary to perform a complete mission analysis. This laboratory houses hot benches for several helicopter types, provides all the necessary ground and flight instrumentation and has a complete aircraft communication suite including the LAMPS datalink. It also houses several computer systems with the latest data storage and retrieval technology used for real-time or post flight data recovery and analysis. The HMSSC maintains and provides the most modern test instrumentation and measurement equipment.

The Automated LAMPS Data Integrated Network (ALADIN) is located within the Helicopter Mission System Support Center, to aid in providing engineering and technical support to test and evaluate the LAMPS MK III helicopter. ALADIN performs the task of converting magnetic tape-recorded data into engineering units that can be tabularized, plotted, or summarized in statistical form. The aircraft data extraction program automatically logs parameters required by each subsystem functional area to analyze subsystem performance. The ALADIN system can retrieve any of the 77 different stored messages and plot and/or tabularize the data.

The HMSSC house two avionics test benches. The AN/ASN-123 TACNAV test bench and the SH-2G System Test Bench (STB) are used to test tactical data transfers with other ASN-150 and ASN-123 platforms. These test benches are utilized to troubleshoot problems, explain new software updates to the aircrew and to replay tests. They are fully interconnectable via 1553 data busses and can simulate a variety of conditions found on the aircraft.

3.2 TEST RESULTS REPORTS

Software problems are reported to the sponsor and the Software Support Activity (SSA) via Software Trouble Reports (STRs) or Software Change Requests (SCRs). An STR is used for reporting an identified software discrepancy or to request a maintenance change or analysis of a problem of unknown origin, (i.e., software is not operating according to approved specifications). An SCR is a request for a minor enhancement (i.e., the need is not contained in an approved specification, but requested to be implemented in the software). All system problems discovered during DT&E (whether hardware or software) are reported in Board of Inspection and Survey Yellow Sheet Deficiencies Reports.

Test results are reported via officially approved test reports. NAWCAD has four types of reports used to communicate test results between testers, developers and program sponsors. The four types of reports are:

- Quarterly Status Report
- Message Report
- DT/OT Transition Report
- Report of Test Results

All reports presents technical information in different formats depending on what data and how much data the sponsor requires. Decisions on which type of reports to publish are established with the project sponsor during the project preliminary phase before DT&E.

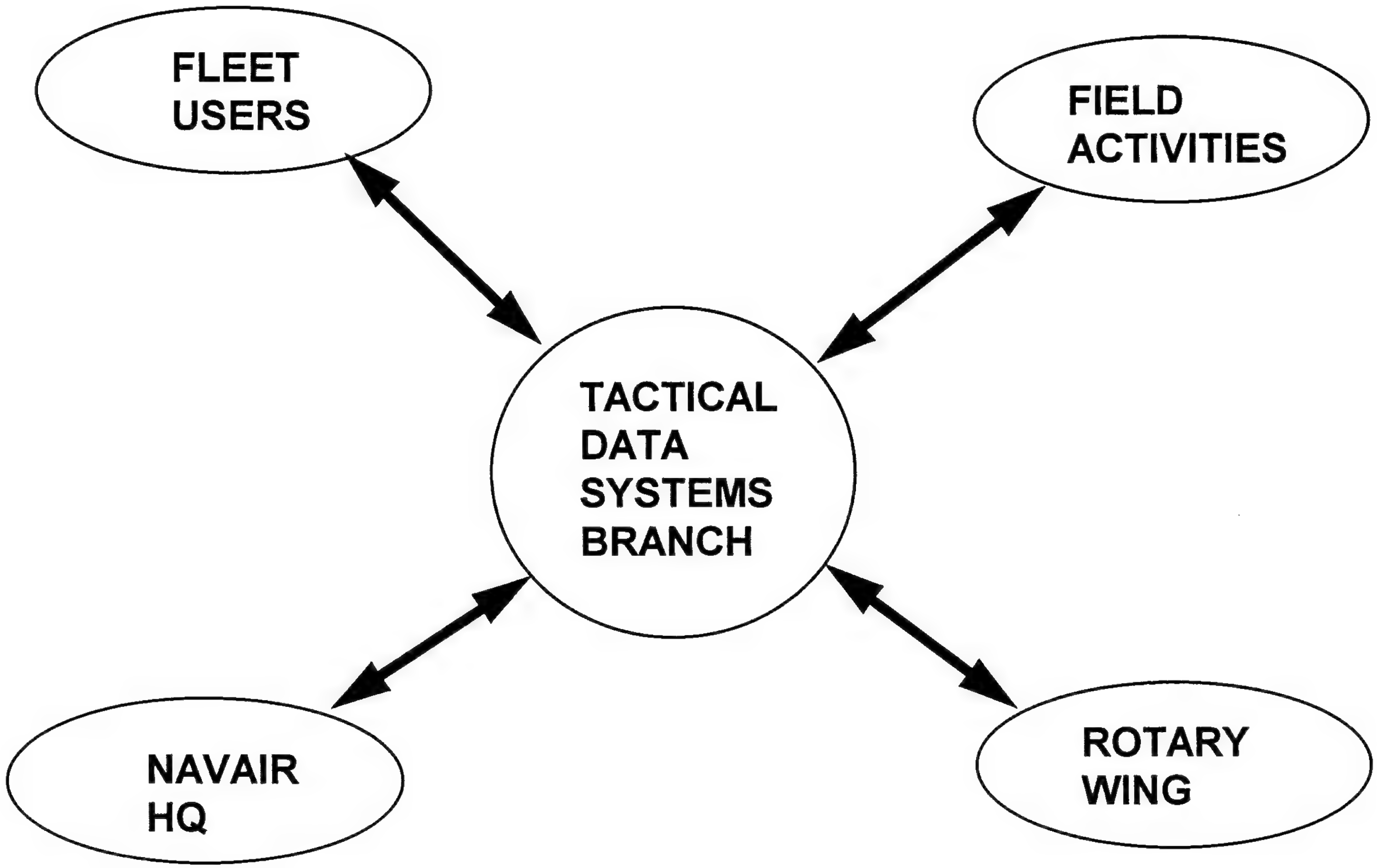
4.0 CONCLUSION

DT&E engineers from a competency-aligned organization such as TDSB, use test plans, modern laboratories, test instrumentation and data collection facilities to evaluate software used on fleet configured aircraft operated by Navy aircrew. The successful development and testing of software to operate Navy helicopters are necessary for the timely delivery of software-based technology to the fleet.

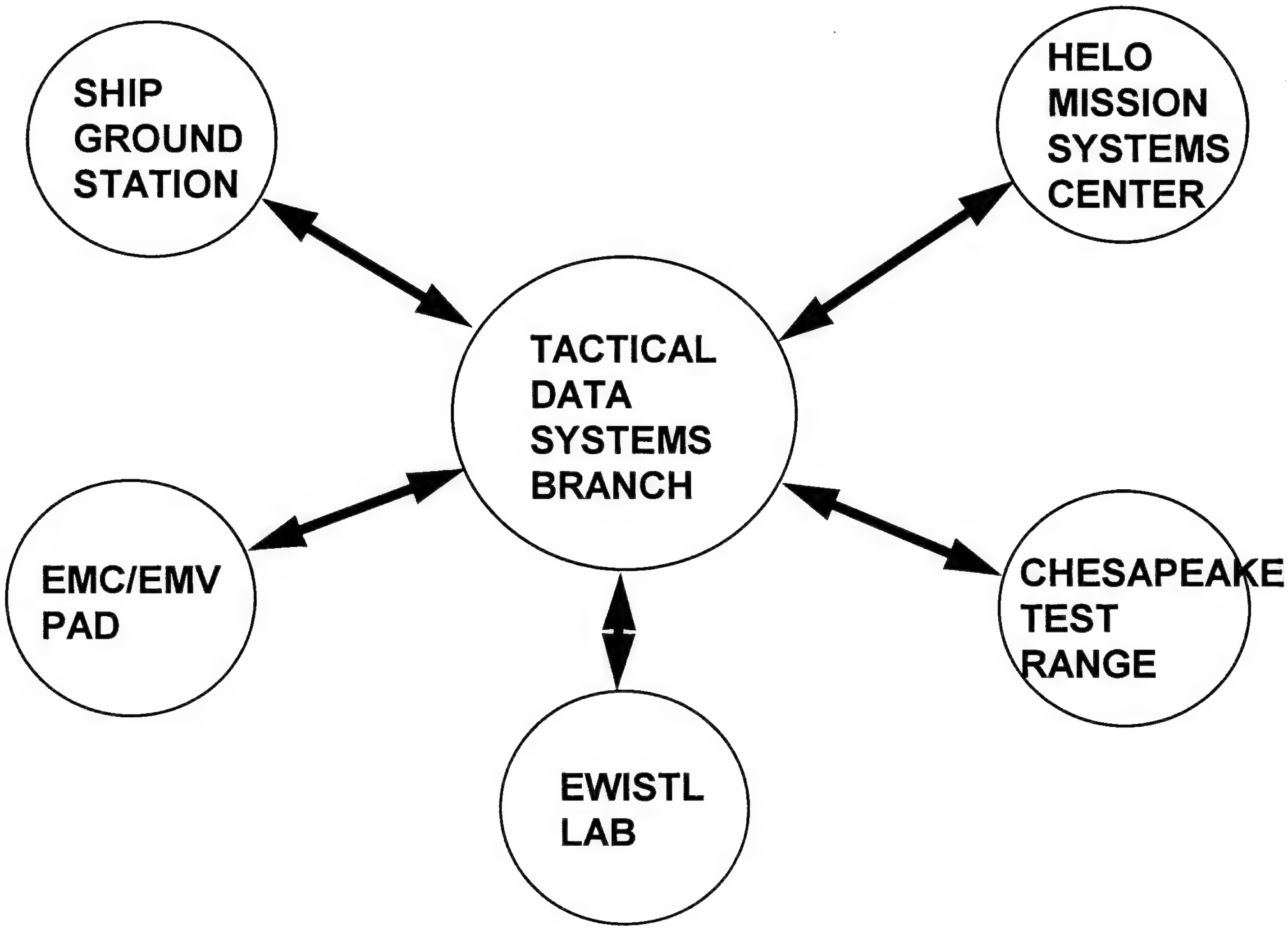
The TDSB has been providing the personnel, processes and facilities for IPTs that are responsible for supporting the software life cycle on a variety of helicopters. Advanced software systems of today require detailed management throughout the software life cycle. Test planning along with the use of scripted scenarios enables DT&E engineers to evaluate complex software.

Testing in the near-operational environment is a proven and effective way of detecting functional anomalies of new software products, allowing corrections before the fleet issue release. This has proven to be a key value added step for military software IPTs.

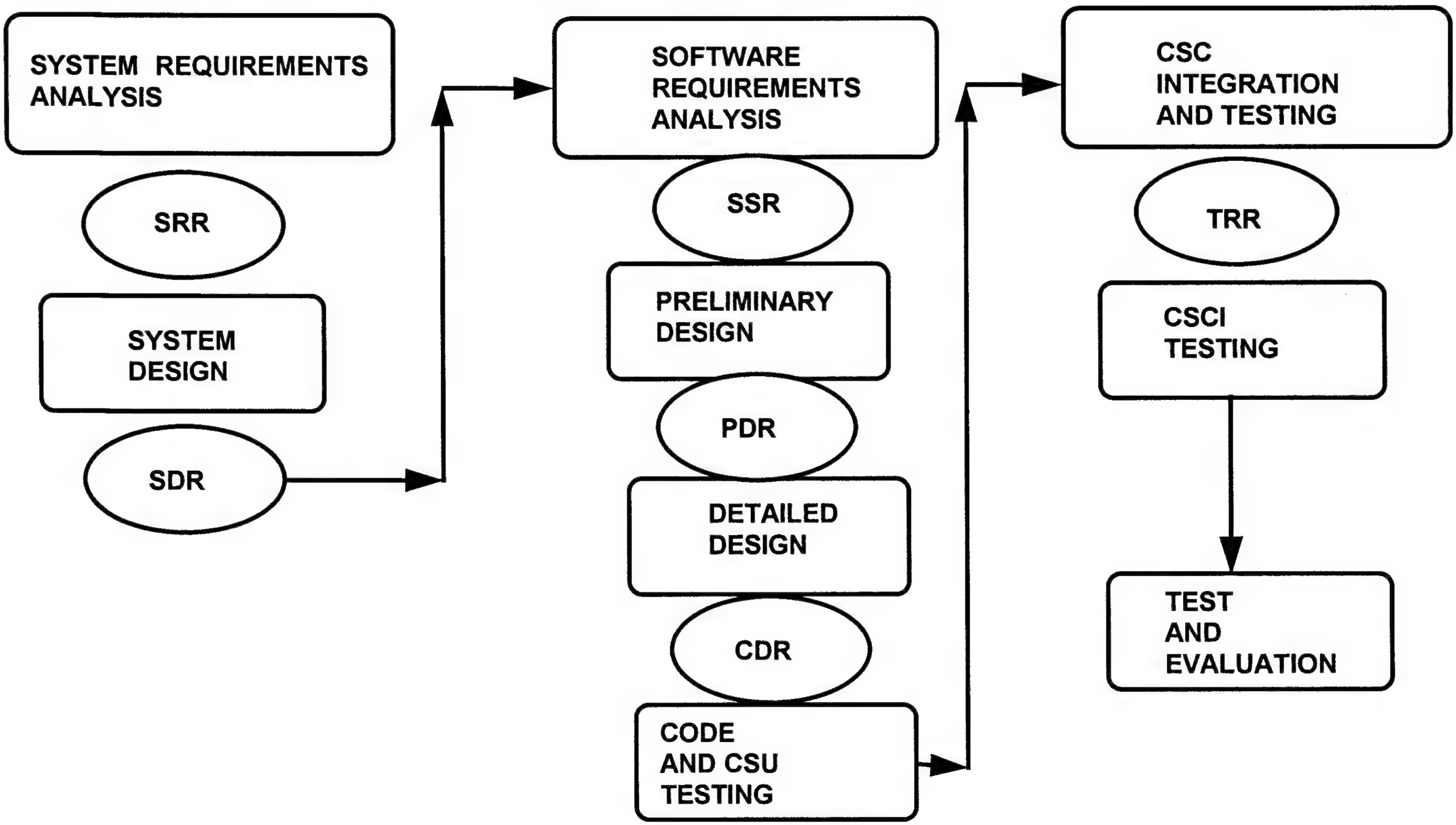
THE TEAM CONCEPT



THE ROTARY WING CONNECTION



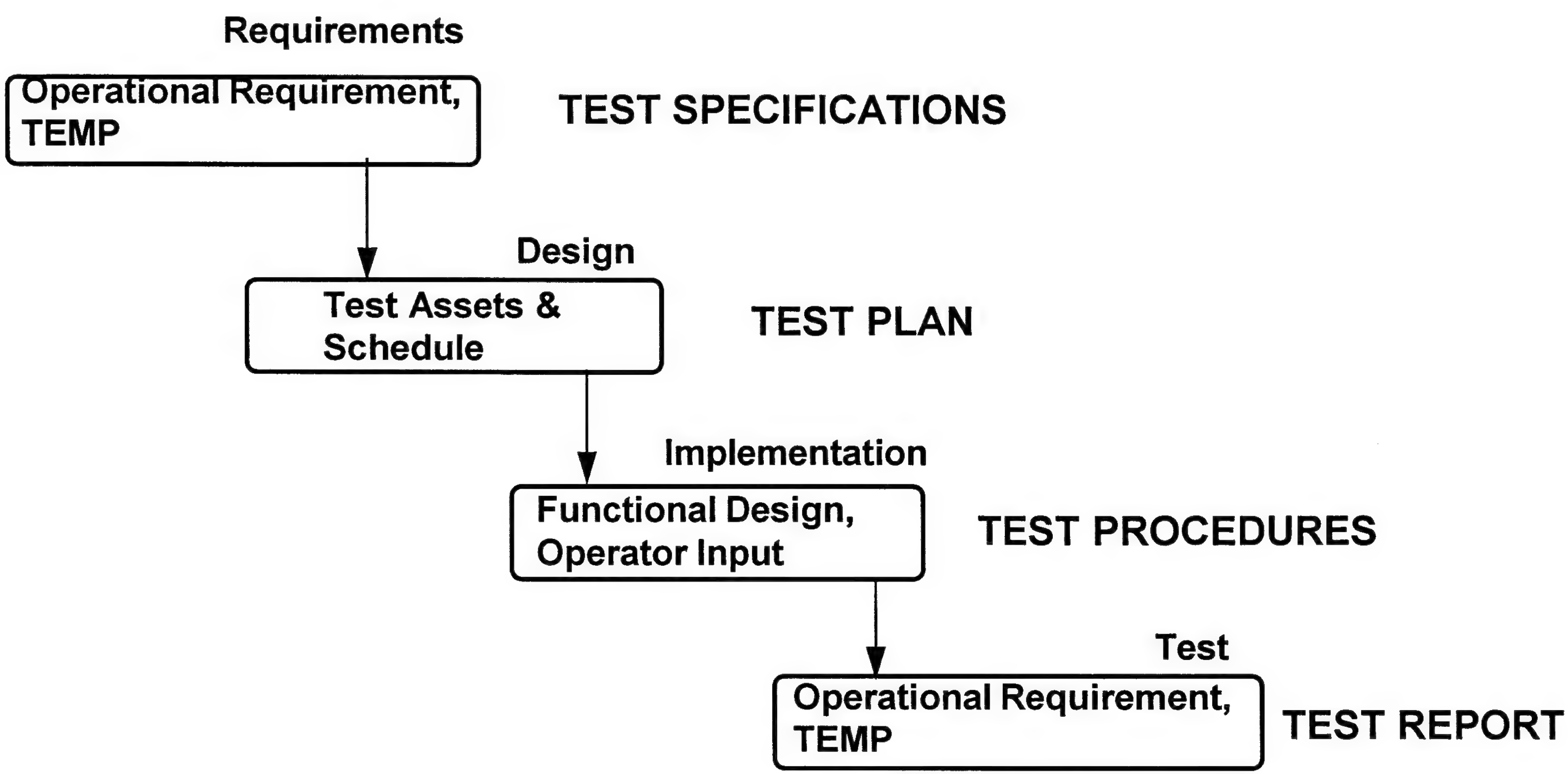
AUDITS AND REVIEWS



Software Development Activities

- System Requirements Analysis
- System Design
- Software Requirements Analysis and Design
- Preliminary Software Design
- Detailed Software Design
- Coding, Unit and Module level testing
- Developmental Testing

Developmental Testing



Software Lifecycle

SYSTEM	SOFTWARE
Concept Exploration	System Requirements
Demonstration and Validation	Subsystem Requirement
Engineering and Manufacturing	Design, Code and Test
Full Rate Production	Modification
Operational Capability	Modification/ Maintenance

Test and Evaluation Factors

- Subject
- Criteria
- Procedures and Controls
- Setting

Software Design

- Initialization Data
- Loading Data
- Built-In-Test
- Data Entry
- Display and Control

Data Entry Designs

- Keyset Only
- Menu Driven

Test and Evaluation Approaches

- System Performance
- Crew-System Interface
- Software Reliability
- Software Safety

Data Collection

- Manual Methods
- Instrumentation
  - Data Bus
  - Audio / Visual
- Mission Recorders / Data Extraction

Laboratories

- Ship Ground Station
- Chesapeake Test Range
- Helicopter Mission Systems Support Center

Test Benches

- ALADIN
- SH-2G (AN / ASN-150)
- SH-3H / SH-2F
  TACNAV (AN / ASN-123)

Reports

- Quarterly
- Naval Message
- DT / OT
  Transition Report
- Report of Test Results

Conclusions

Go Navy !